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PERFORMANCE EVALUATION OF A POLYETHYLENE FOAM SHIPPING CONTAINE--ETC(U)
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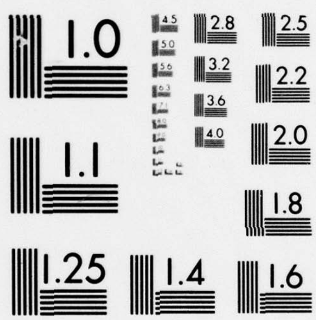

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14 PTPT-78-12

6 PERFORMANCE EVALUATION OF A POLYETHYLENE FOAM SHIPPING CONTAINER FOR THE F-16 EMERGENCY POWER UNIT HYDRAZINE FUEL TANK,

HQ AFALD/PTP
AIR FORCE PACKAGING EVALUATION AGENCY
Wright-Patterson AFB OH 45433

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NOTICE

ABSTRACT

In support of ASD/AEGT, this Agency subjected a prototype polyethylene foam container for the F-16 Emergency Power Unit (EPU) hydrazine fuel tank, to a series of performance tests in accordance with Federal Test Method Standard 101B.

The objective of these tests was to determine if the prototype container would protect the EPU fuel tank from mechanical damage and maintain a vapor seal, i.e., a minimum 1.0 psig pressure during all phases of testing.

The container was subjected to repetitive shock and vibration, compression loading, free fall drop (ambient and low temperature), and leak tests. These tests indicate the EPU container will maintain the 25 G shock protection level required during all phases of transportation. However, the container gasket seal failed to maintain the prescribed pressure during all phases of testing.

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INTRODUCTION

The Aeronautical Systems Division Test Equipment Group (AEGT), requested this Agency subject a prototype container for the F-16 Emergency Power Unit (EPU) Hydrazine Fuel Tank to a series of shipping and handling tests. The purpose of this shipping container is to protect a fuel tank containing approximately 6.6 gallons of H-70 hydrazine during worldwide distribution.

CONTAINER/ITEM DESCRIPTION

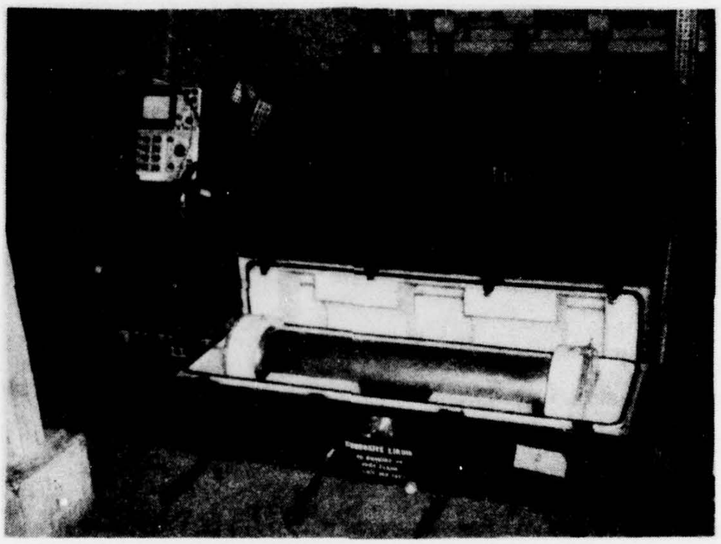

FIGURE 1. Opened container showing internal cushioning configuration

The prototype container is fabricated from polyethylene of 2 lb. and 9 lb. density compatible with hydrazine (Figure 1). Polyethylene end caps (9 lb.), with plywood load spreaders, protect the quick-disconnect fittings on either end of the fuel tank (Figures 2 and 3). The fuel tank is nested in a saddle constructed of 2 lb. polyethylene material. The container walls are 2.25" thick, consisting of 3/8" polyethylene (9 lb.) on the outer surface, laminated to 1 7/8" polyethylene (2 lb.) on the inner surface. The container incorporated four retaining nylon straps with buckle-type securing devices.

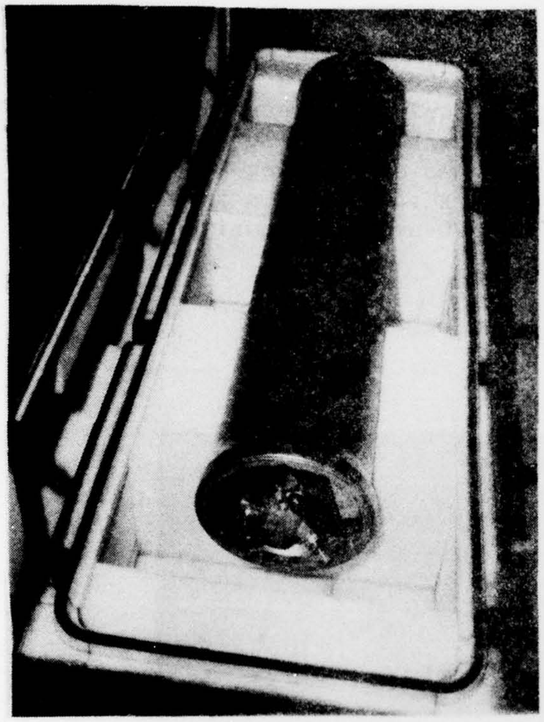

FIGURE 2. Fuel tank nested in container, showing quick-disconnect fitting

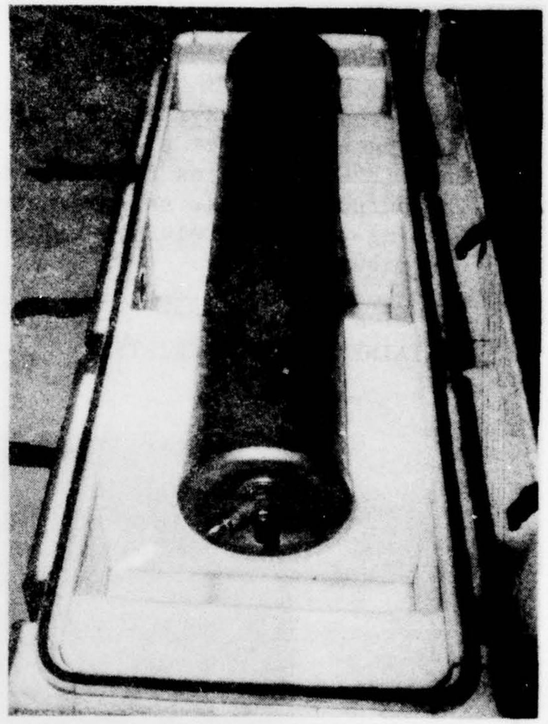

FIGURE 3. Quick-disconnect fitting protruding from fuel tank

The container exterior dimensions are 57.5" x 20.0" x 21.2". The weights of the container and contents are as follows:

Container (empty)	-	46.5 lbs.
Fuel tank (empty)	-	39.5 lbs.
H-70 hydrazine	-	55.0 lbs. (6.6 gal.)

The hydrazine fuel tank normally contains a movable piston. However, the piston was missing in the fuel tank sent to this Agency for test. During the phase of testing requiring a loaded fuel tank, water was substituted for the hydrazine. Water and hydrazine have a specific gravity of 1.0, thus assuring an identical loading situation.

DESCRIPTION OF TEST EQUIPMENT AND INSTRUMENTATION

The following equipment and instrumentation was used:

Equipment

a. Vibration Test Machine, Type 5000-96B, L.A.B. Corp.

b. High Capacity Compression Tester, Model 17-24, Testing Machines, Inc.

c. Electrostatic Monitor, Model ST-50, Deltron Instrument Co.

d. Gaynes Drop Tester, Model 125 DTP, Gaynes Engineering.

Instrumentation

a. Accelerometers (3 ea.), Model 2233E, Endevco Corp.

b. Charge amplifiers (3 ea.) Model 2614C, Endevco Corp.

c. Power supply, Model 2622C, Endevco Corp.

d. Manometer, Well Type, Model 30EB25, Meriam Instrument

e. Storage Oscilloscope, Type 564B, Tektronic, Inc.

TEST PROCEDURES

Scheduled Tests (AEGT Test Plan):

The prototype container was subjected to the following tests in accordance with Federal Test Method Standard 101B:

Test	Test Method
Leak Test	5009
Pneumatic Pressure Test	5009
Vibration (Repetitive Shock)	5019
Superimposed - Load Test	5016
Free Fall Drop Test (Corner Drop)	5007

Inspection

During initial inspection, it was noted that the prototype container was intact and no damage had been incurred during shipment. An inspection was made prior to and following each test to ascertain container integrity.

Pneumatic Pressure and Leak Test (Method 5009)

A leak test was conducted prior to and following each shipping and handling test. A 1.0 psig pressure was applied to the container through a fitting in the container wall. This pressure was monitored by means of a water manometer. A positive seal is indicated if the water in the manometer does not fall below 27.5 inches when the external pressure is terminated. A soap bubble test was conducted if a positive seal was not obtained, to identify the points of leakage.

Results: When the container was pressurized, prior to initiation of the shock and vibration testings and the external pressure terminated, the water in the manometer fell sharply indicating a leak in the container. The soap bubble test revealed the container wall and the gasket seal were leaking. Efforts to seal the container wall failed. Subsequent pressure checks after each phase of testing revealed additional points of leakage at different locations.

Vibration - Repetitive Shock (Method 5019)

The container with test load was subjected to a table displacement of 1.0 inch double amplitude and frequencies ranging between 3 and 5 cycles per second (Hz). Restraining devices were attached to the platform to prevent the container from moving off the platform. The platform vibration was started at a frequency of 3 cycles per second (Hz) and steadily increased until a feeler gauge of 1/16 inch thickness could momentarily be slid between every point of the container surface adjacent to the platform. The maximum platform acceleration was 1 ± 0.1 G.

Results: The rotation of the empty fuel tank within the container was observed to be 75 to 80 degrees and 175 to 180 degrees for the filled fuel tank. However, inspection following the tests indicated no damage to the container. The test results are presented as follows:

CONTAINER WITH:	TEST PERIOD	TABLE DRIVE FREQUENCY (Hz)	RESULTANT (G's)
Fuel Tank Empty	2 hrs.	4.8 to 5.0	5 to 6
Fuel Tank Filled	*1 hr. 32 min.	5.0 to 5.3	6 to 7

*The vibration test was terminated prematurely due to water leaking from the fuel tank within the container. This was due to gaskets omitted from the fuel tank.

Superimposed-Load Test (Method 5016)

The container was placed on the High Capacity Compression Testing Machine and a load applied equal to that produced when like containers are stacked to a height of 16 feet. The compression machine was programmed for the constant loading mode, at a uniform force of 1269 lbs. for a period of one hour.

Results: The maximum deflection measured under load after the one hour test period was 1/2 inch. The maximum lateral deflection was 1/8 inch during the constant loading mode. Container inspection after testing indicated no container damage.

Drop Test (Free Fall) (Method 5007)

The container with fuel tank was dropped once on each of its eight corners from a drop height of 18 inches. This test was conducted with the fuel tank both empty and filled. The container was also subjected to flat drops from a height of 18 inches on face 3 and face 4. The flat drop was repeated for a series of two drops.

The container with fuel tank (filled) was also dropped on each end (faces 5 and 6) from a drop height of 48 inches (flat drop). This procedure was repeated for two drops. Because of instrumentation problems, reliable data was obtained on only two of the four drops.

The container with fuel tank (filled) was subjected to a low temperature corner and flat drop test series from a height of 18 inches. The container with fuel tank was placed in a cold chamber for a period of four hours at a temperature of -40°F. The drop test series consisted of four corner drops and three flat drops.

Results: The results of the free fall drop tests are presented in Table I. Tests conducted at ambient temperature from a drop height of 18 inches indicate the container can protect the fuel tank from damage and maintain the required shock protection level of 25 G. From a drop height of 48 inches, the container will protect the fuel tank from damage but cannot maintain the 25 G shock protection level.

Low temperature drops ($-40^{\circ}F$) from 18 inches resulted in significantly increased shock transmission as well as container damage.

During the corner drops, the movement of the container halves relative to each other was 1/4 inch with the fuel tank empty and 1/2 inch with the filled tank. The corners of the container deformed slightly after each corner drop but recovered.

The container was inspected after each series of drop tests. The container was damaged during the low temperature corner drop tests (Figures 4 and 5). The polyethylene material separated, damaging the gasket seal in two places. The separation was in the form of a material failure rather than that of a glue joint. The damage was attributed to the rigidity of the material at low temperature.

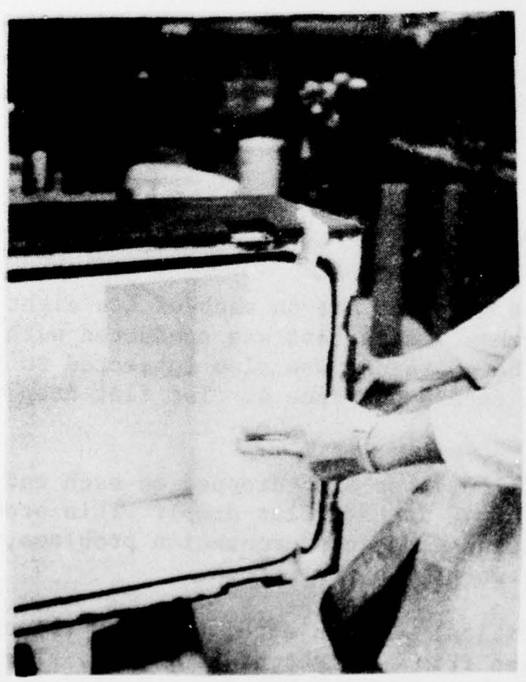

FIGURE 4.

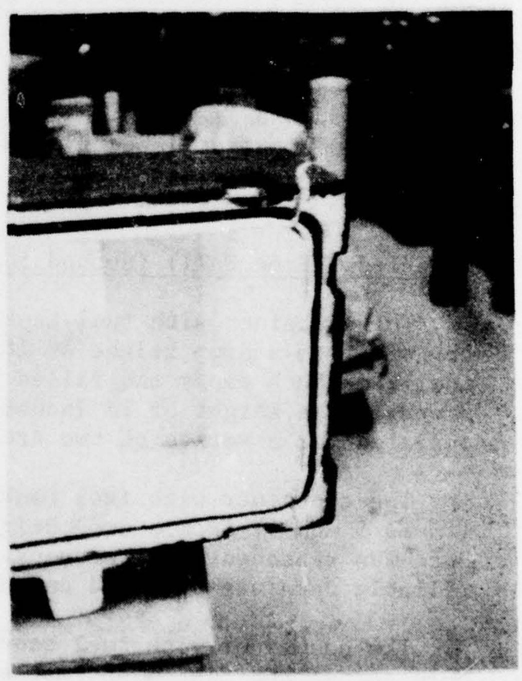

FIGURE 5.

Container damage resulting from the 18" low temperature corner drops.

TABLE I - DROP TEST (FREE FALL)

DROP HEIGHT	IMPACTED FACE OR CORNER	X AXIS G's	Y AXIS G's	Z AXIS G's	RESULTANT G's
18 Inches			Tank Empty		
	1-5-2	14	5	5	15.7
	1-6-4	8	2	8	11.5
	1-5-4	12	3	3	12.7
	1-6-2	14	5	8	16.9
	2-5-3	10	2	2	10.4
	6-4-3	10	6	8	14.1
	4-5-3	10	2	3	10.6
	2-6-3	10	8	5	13.7
				Average	13.2
18 Inches			Tank Filled		
	1-5-2	9	1	3	9.5
	1-6-4	5	7	4	9.4
	1-5-4	8	3	5	9.9
	1-6-2	8	6	3	10.4
	2-5-3	8	2	3	8.7
	6-4-3	5	8	6	11.2
	4-5-3	11	5	3	12.4
	2-6-3	5	7	8	11.7
				Average	10.4
18 Inches			Tank Filled		
	3	3	11	19	22.1
	3	10	10	24	27.8
				Average	24.9
	4	7	27	8	29.0
	4	5	2	17	17.8
				Average	23.4
Low Temp.-40°F 18 Inches			Tank Filled		
	1-2-6	17	20	25	36.2
	1-4-6	12	19	18	28.8
	4-5-3	11	0	19	22.0
	2-5-3		4	4	19.8
				Average	26.7
	3	20	21	5	29.4
	4	28	15	10	33.3
	5	20	10	25	33.5
				Average	32.0
48 Inches			Tank Filled		
	5	42	8	8	43.5
	6	35	20	20	45.0

ADDITIONAL TESTS

Drop Test (Free Fall)

This test was conducted in addition to the test plan submitted to this Agency by AEGT. The test was performed to obtain data relating to the concern of AFALD/PTE that the container might experience an accidental drop from 48 inches when the tank is being placed on the aircraft. A flat drop from 18 inches was also conducted since prior experience has indicated that flat face impacts commonly occur and usually result in higher shock inputs.

The polyethylene end cap design is such that a clearance of no more than 1/8 inch is provided between the quick-disconnect fitting protruding from the end of the tank (Figure 3) and the surface of the end cap plywood load spreader. Although the polyethylene end cap is relatively stiff, there was still some concern that the material would deform enough at impact to permit the tank fitting to make contact with the plywood load spreader. If this occurred, the high localized stress developed could damage the tank fitting.

To determine whether contact occurred during drop testing, a piece of carbon paper was affixed to the surface of this plywood load spreader. Contact of the tank fitting with the plywood load spreader would leave an identifying mark.

Results: The fitting made contact with the plywood load spreader during the 48-inch flat drop test. The impression left by the carbon paper was clear, but the plywood was not indented (see Figure 6).

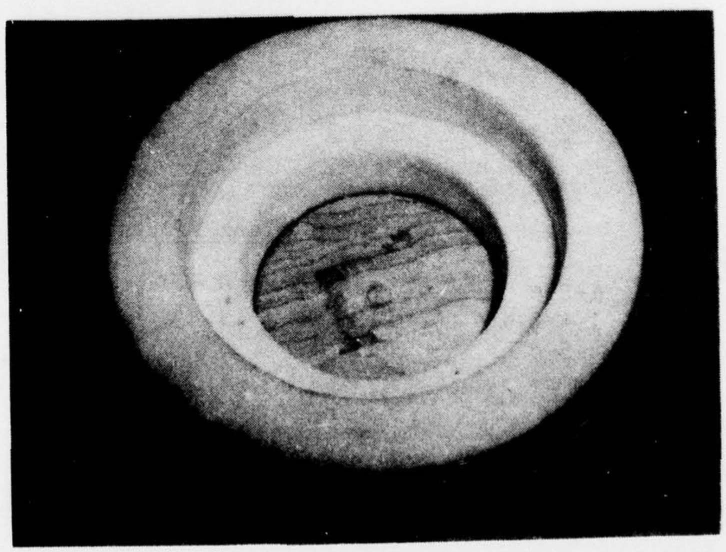

FIGURE 6. View of end pad showing carbon paper impression on plywood load spreader.

Electrostatic Measurement

Various points inside and outside the container were monitored before and after vibration testing. These readings were taken to determine values of static electricity in volts (rms) generated during the vibration tests.

READINGS IN VOLTS (rms)

Measurement Point	Before Test	After Test
Outside container	0.0	400
Inside container	375	600
Inside container	300	255
Inside container	100	175
Inside container	225	500
Fuel Tank Surface	0.0	275

DISCUSSION

During the drop test (free fall) on each corner of the container, it was noted that the nylon straps securing the container halves allowed the two container halves to move relative to each other. This flexibility is desirable for this type of container design. Hinges and fastener securing devices, incapable of this flexibility, could introduce a highly localized stress causing container damage.

The deflection problem of the fuel tank previously described will be eliminated through redesign of the end pads. AEGT has indicated that the plywood load spreaders will be eliminated in the new design and the pad will provide appropriate clearance for the quick-disconnect fittings.

CONCLUSIONS

Based on the test results, it is concluded that the container will protect the fuel tank during transportation and handling at moderate temperatures but not at extremely low temperatures, i.e., $-40^{\circ}F$ or less. Also, the container cannot provide the required vapor seal at 1.0 psig pressure differentials.

RECOMMENDATIONS

a. Gasket seal be redesigned to maintain the prescribed 1.0 psig pressure.

b. Investigate a new molding process for polyethylene material developed by Kaneka American Corporation, 1251 Avenue of the Americas, New York NY 10020.

The molding process would reduce the labor involved in fabricating a varied density polyethylene container from sheet stock. The elimination of glue joints would strengthen the structure of the container while reducing the cost.

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Hydrazine tank container; rough handling tests

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

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